Aerial Magnetometer Survey Work Plan

for

Helicopter-borne Magnetometer Digital Geophysical Mapping in Support of Active Army Military Munitions Response Program Field Demonstration of Wide Area Assessment Methods at Closed Castner Firing Range, Fort Bliss, TX

Draft Final

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Submittal Date: November 21, 2009

Version 2.0

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ACRONYMS

3D	Three-Dimensional
AGL	Above Ground Level
AMS	Aerial Magnetometer Survey
AMSWP	Aerial Magnetometry Survey Operations Plan
AOI	Area of Interest
ATC	Air Traffic Control
CD	Compact Disc
cm	centimeter(s)
DAS	Data Acquisition Software
dBA	Decibels (on the A Scale)
DFOW	Definable Features of Work
DQO	Data Quality Objective
DVD	Digital Video Disc
ETA	Estimated Time of Arrival
F	Fahrenheit
FAA	Federal Aviation Administration
GIS	Geographic Information Systems
GPS	Global Positioning System
HASP	Health and Safety Plan
HeliMag	Helicopter Magnetics
Hz	Hertz
IVS	Instrument Validation Survey
LiDAR	Light Detection and Ranging
m	meter(s)
MEC	Munitions and Explosives of Concern
mm	millimeter(s)
NGS	National Geodetic Survey
nT	nanoTesla
OSHA	Occupational Health and Safety Administration
pdf	Portable Document Format
PIC	Pilot in Command
PPE	Personal Protective Equipment
QC	Quality Control
QCP	Quality Control Plan
RTK GPS	Real Time Kinematic Global Positioning System
SAR	Search and Rescue
SKY	Sky Research, Inc.
SOP	Standard Operating Procedure(s)
SSM	Site Suitability Model
URS	URS Group Inc.
USACE	US Army Corps of Engineers
UXO	Unexploded Explosive Ordnance

1.0 INTRODUCTION

This Aerial Magnetometer Survey Work Plan (AMSWP) describes the planned airborne geophysical survey utilizing helicopter magnetics (HeliMag) in support of Active Army Military Munitions Response Program Field Demonstration of Wide Area Assessment Methods at Closed Castner Firing Range, Fort Bliss (Figure 1). This work is being performed by Sky Research Inc (SKY), under contract to URS Group Inc (URS). The objective of this subcontract is to demonstrate the costs and benefits of applying helicopter-borne magnetometer as WAA methods on an Active Army Military Munitions Response Program (MMRP) site. This project will demonstrate helicopter-borne magnetometer as described in the *Wide Area Assessment Cost-Benefit Analysis: Active Army Military Munitions Response Program* conducted by the USAEC in 2007-2008. Work performed under this subcontract will provide the Army with the digital geophysical mapping (DGM) data to meet the requirements of a CERCLA remedial investigation (RI) for the Closed Caster Firing Range, Fort Bliss, TX.

SITE DESCRIPTION

1 General

Castner Range is located within the northern limits of the city of El Paso, El Paso County, Texas. The range is bordered on three sides by residential and commercial development and on the west by the Franklin Mountains State Park. It is comprised of 7,007 acres, of which 1,577 are predicted to be suitable for investigation using the HeliMag technology.

2 Geologic Conditions

Geological information and site observations suggest that the majority of the site consists of geologic strata with low ferrous-mineral content, which should afford favorable conditions for a survey of magnetic material.

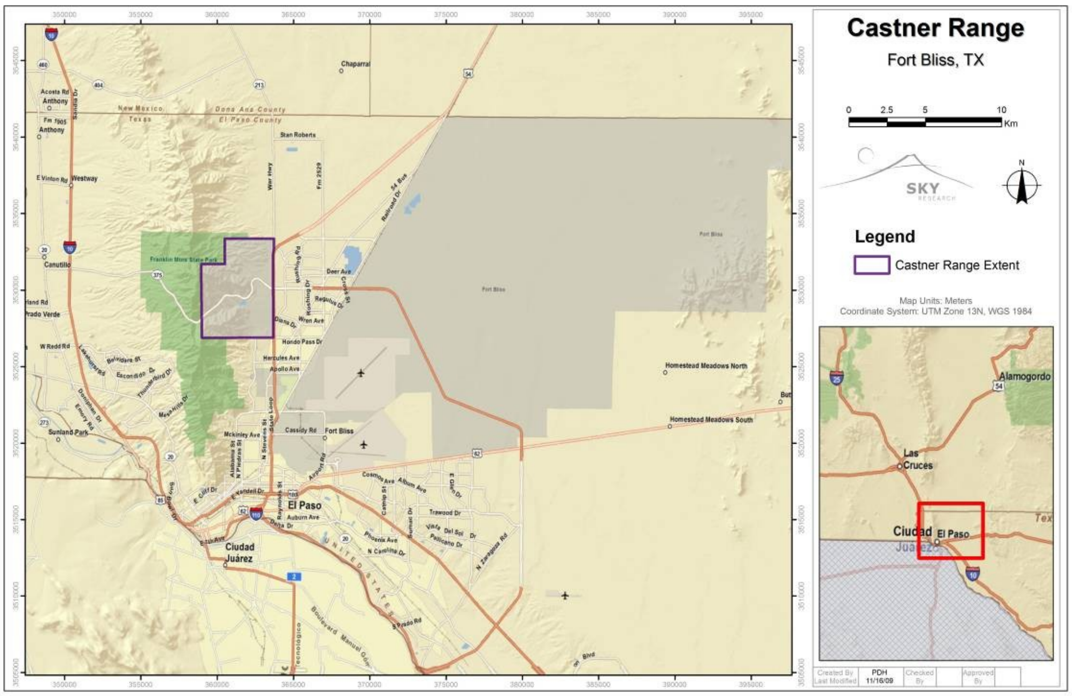

Figure 1. Proposed HeliMag survey boundary at the Castner Range at Ft Bliss TX.

3 Topography and Vegetation

Topography and vegetation are the primary determinants of the HeliMag survey altitude. Much of the Castner Range is too rugged to be suitable for effective HeliMag investigation as shown in red in Figure 2. A site suitability model based upon recent LiDAR data collected in 2006 predicts that a total of 1577 acres are suitable for the HeliMag technology.

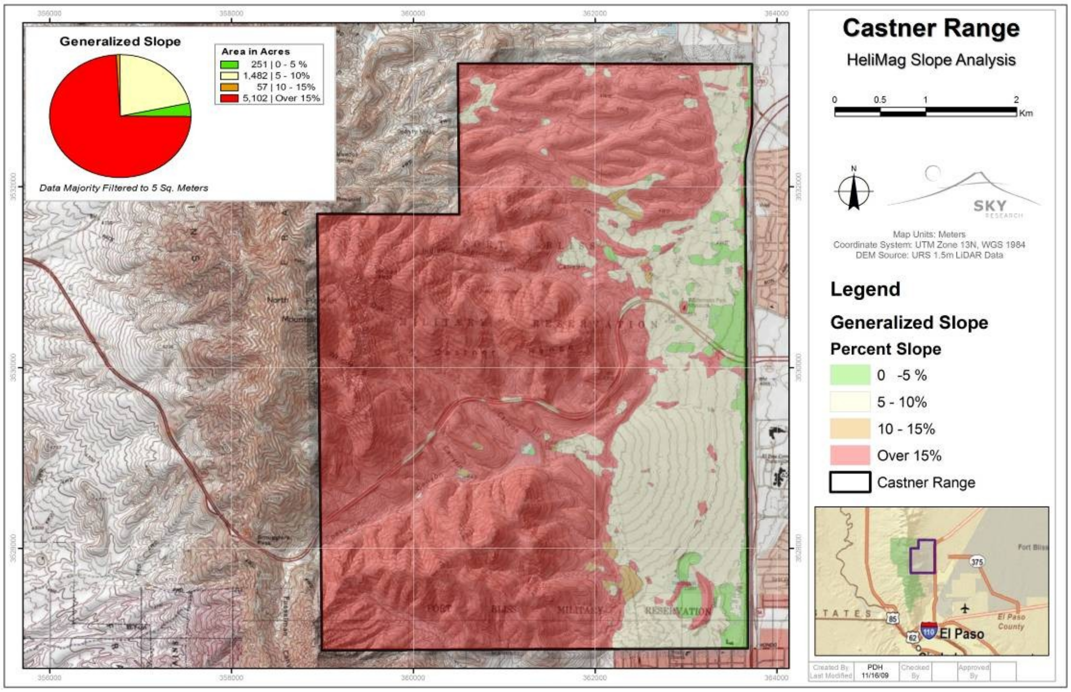

Figure 2. Site Suitability Model.

4 Anthropogenic Features Potentially Affecting Geophysical Investigations

Anthropogenic features such as buildings, power lines, fences and pipelines generally have characteristic magnetic signatures that mask and/or distort the response of MEC-like objects. After data are collected, the effects of these surface and subsurface features are routinely identifiable in the data, and manifest as linear, curved or very large anomalies. Although, in some cases, the deleterious effects of these features on the survey results can be mitigated during the processing of the data, areas affected by these features are commonly identified and excluded from the final data maps and interpretation.

4.1 Site-Specific Dynamic Events Affecting Geophysical Investigations

Dynamic events (rain, lightning, solar flares, etc.) may temporarily impact geophysical data collection and/or data quality. Procedures for these anticipated events are as follows:

- **Rain**: Rain is a hazard to crew and equipment primarily due to its effect on visibility conditions. During periods of rain, the Pilot in Command (PIC) will assess the intensity and determine when or how to proceed with survey operations. When surveying stops, the field activity log will reflect the conditions and reasons for the stoppage. Once the rain ends, and time permitting, the survey will resume.
- **Lightning**: Lightning is a severe hazard to the health and well-being of field crews. Site personnel and equipment will take shelter in a safe area. Geophysical team members will make the determination that lightning is present, annotate the survey activities log and shut down field operations until the threat passes.

- **High Winds**: High winds present a safety hazard to airborne survey operations. The PIC will determine if hazardous wind conditions exist and will terminate airborne survey activities. Once workable conditions return, work will resume.

5 Overall Accessibility and Impediments

The site is easily accessible by air, and no accessibility issues are anticipated.

6 Potential Worker Hazards

All site personnel will adhere to the practices, procedures, and training and monitoring requirements mandated by the Health and Safety Plan (HASP) presented in section 4 of this document.

2.0 AIRBORNE GEOPHYSICAL SURVEY

7 Geophysical Survey Objective

SKY will utilize 100% coverage surveys for the detection of surface and subsurface ferrous material consistent with possible MEC items of interest at this site. These data will be used to characterize the site with respect to the density distribution of ferrous material across the site.

8 Geophysical Equipment

8.1 Helicopter Survey Platform

SKY will deploy a helicopter-borne magnetometer array commonly referred to as the HeliMag system. The HeliMag sensor booms are constructed from Kevlar and carbon fiber, making them lightweight and durable. The HeliMag platform is equipped with seven Geometrics G-822 cesium vapor magnetometers spaced 1.5 m apart, two Trimble MS750 real-time kinematic global positioning systems (RTK GPS) receivers that provide positions and platform attitude at 10 Hertz (Hz), with up to four altimeters for recording the altitude of the platform. The HeliMag system utilizes a state of the art Data Acquisition System (DAS) that logs data at 400 Hz. The DAS has integrated pilot guidance software that displays the platform position and altitude information relative to the pre-determined flight lines.

8.2 Cesium Vapor Magnetometers

Magnetometers are used to detect perturbations in the Earth's magnetic field caused by ferrous metallic objects. The Geometrics G-822 and G-858 magnetometers are optically pumped cesium vapor instruments that measure the intensity of the Earth's magnetic field in nanoTeslas (nT). Anomalies in the Earth's magnetic field are caused by remanent or induced magnetism. Remanent magnetism is caused by naturally occurring magnetic materials. Induced magnetic anomalies result from induction of a secondary magnetic field in a ferromagnetic material (e.g., pipes, drums, MEC) by the Earth's magnetic field. The shape and amplitude of an induced magnetic anomaly over a ferromagnetic object depend on the geometry, size, and depth. Induced magnetic anomalies over buried objects generally exhibit an asymmetrical, south high/north low, signature. Magnetic anomalies caused by buried metallic objects have dimensions much greater than the dimensions of the objects themselves.

8.3 Geophysical Positioning Methods

SKY uses Trimble MS750 RTK GPS receivers to accurately position the geophysical sensor data. GPS technology uses satellite-based broadcasts to derive the antenna's 3-dimensional (3D) position on the surface of the Earth. Using a local GPS base station to provide real-time differential corrections via a radio link, accuracies of 2 centimeters (cm) are achieved with this technology. The DAS uses the GPS time message and highly precise timing pulse to discipline its internal clock to GPS time. All sensor data are time stamped with GPS time to be used as the basis for merging sensor measurements based upon their time of applicability.

To use GPS on-site, SKY will employ following actions:

- SKY will use radio repeaters to extend the transmission range of the real-time corrections provided by the local GPS base station.
- SKY will establish temporary control points to perform positional accuracy tests.

All geophysical data collection activities will follow Sky Research's Standard Operating Procedures (SOPs). The HeliMag Operations SOP and associated documentation requirements are provided separately.

9 Personnel

9.1 Personnel on Site

Sky will have, at most, one person that requires on-site escort. This person may need to access the site to place and collect the RTK repeater to support data collection. URS will make sure that sufficient UXO Techs are available to support.

9.2 Airborne Survey Geophysicist

The Airborne Survey Geophysicist has overall responsibility for the day-to-day implementation and management of all geophysical activities required for the work effort. In addition to those duties, he will work with the Project Manager (Section 4.2.1.1) to ensure a successful project. The Airborne Survey Geophysicist coordinates all activities associated with the collection, processing, and analysis of geophysical data; reviews all data processing steps, including filtering, anomaly identification, data modeling and dig lists; and reviews all ground truth data for anomaly correlation and correctness. During the data acquisition phase of the project, the Airborne Survey Geophysicist will perform initial preprocessing and merging of the raw flight data.

9.3 Helicopter Pilot

The Helicopter Pilot-In-Charge (PIC) is responsible for piloting the aircraft in a safe and efficient manner. The PIC has complete control over all aircraft-related operations and emergency response activities and requirements. The PIC has the authority to abort any flight, as well as to deviate from survey specifications (speed, altitude, and/or flight duration) for safety purposes. PIC will coordinate with Ft Bliss and local FAA authorities as directed by URS prior to any flight operations.

9.4 Sensor Operator

The Sensor Operator operates the onboard instrumentation and is responsible for the proper execution of HeliMag activities associated with data collection.

9.5 Ground Support Team Member

The Ground Support team member is responsible for emplacement of calibration targets, set up of GPS base stations and repeaters, delivery of fuel, and flight following. The Ground Support team member is a proficient user of the GPS survey equipment and has been trained in the proper procedures for the above activities.

9.6 Data Processor

After the initial preprocessing and merging of the raw flight data (performed on site by the project geophysicist), the Data Processor is responsible for processing all the geophysical data using the site specific data processing procedures and filing all the appropriate data processing paperwork. The Data Processor does not need to be on-site to perform these tasks. Sky Research makes extensive use of its internal FTP site and the Data Processor will have access to the pre-processed, merged data within a few hours of the completion of each survey flight.

9.7 Quality Control Geophysicist

The Quality Control (QC) Geophysicist is responsible for ensuring all data meet the quality objectives of the project and he will accumulate and submit all of the appropriate QC paperwork. During the initial startup, the QC Geophysicist will work directly with the URS QC Geophysicist to ensure that the data quality and reporting procedures are sufficient to meet the goals of the survey. The QC Geophysicist will have access to all of the data collected via the Sky Research internal ftp site in a timely manner. After the initial startup, the QC Geophysicist does not need to be on-site to perform these tasks.

10 Data Acquisition

10.1 Logistics

10.1.1 Base of Operations

The helicopter will base out of El Paso International Airport. Normal Air Traffic Control (ATC) communications will be used during the takeoff and climb out phase of the data collection flights. The pilot will be in contact with ATC and receive VFR traffic advisories during the flights to and from the survey location and Bear Heliport for refueling. The pilot will also coordinate with Biggs Army Airfield for flight line coordination and restricted airspace requirements. A table highlighting communication agencies is shown in Table 1.

Table 1. Communication with Local Agencies

Communication Agency	Name and Role	Phone Number
El Paso International Airport Tower	Danny Maquez – FAA Staff Support Specialist	915-774-9402
Biggs Army Airfield	Fred Baca – Airfield Operations Manager	915-744-8048
Bear Aviation Heliport	Charles Bella - Owner	915-755-9667

Fuel will be provided to support Sky Research via a DOT approved fuel truck provided by Bear Aviation that is equipped to carry 300 gallons of Jet-A. The fuel truck will be filled at El Paso International Airport as needed through the project and relocated to a FAA approved helicopter landing and refueling zone named Bear Heliport. A map

showing the survey area, airports, restricted airspace, and Bear Heliport is presented in Figure 3.

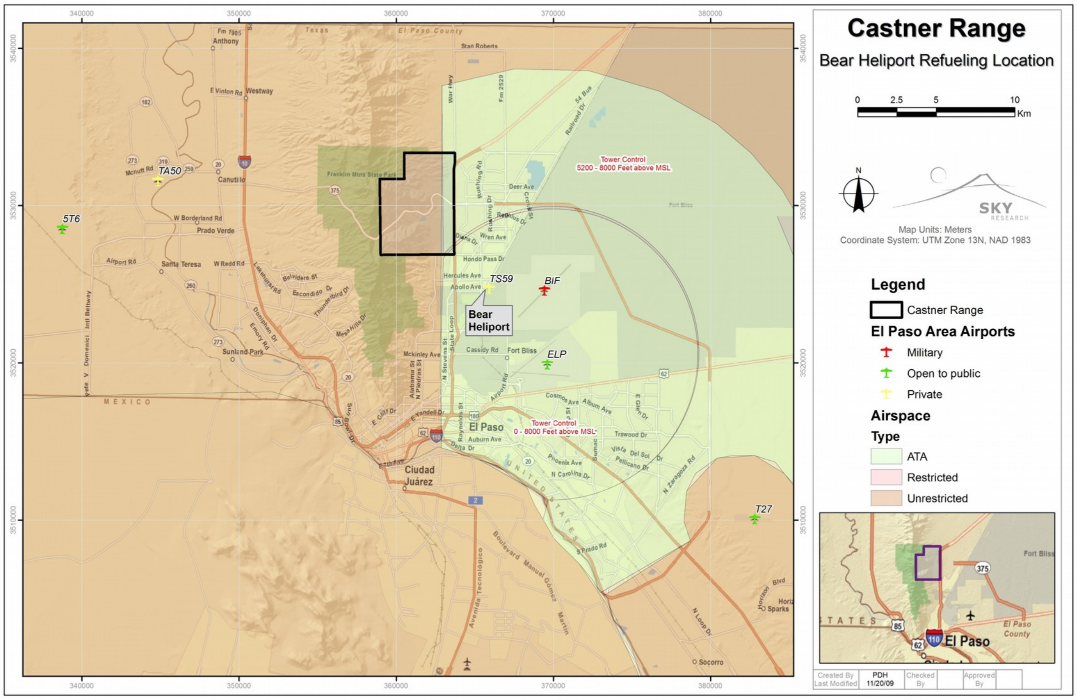

Figure 3. Proposed HeliMag remote staging/refueling sites and restricted airspace.

10.1.2 Beginning and Ending Flight Lines

The HeliMag is not transmitting or emitting anything harmful, the platform is a passive system recording the earth's magnetic field to locate ferrous metal. At the end of a flight line if terrain allows the pilot will gain altitude and perform a tear drop turn into the wind. The apex of the turn will be no more than 300m beyond the end of the flight line at an altitude of 100m. The pilot will then begin descending to achieve the desired flight attitude before starting the next flight line. Flight lines are planned from North to South.

The helicopter will not fly over houses or buildings that are occupied. Flight lines will be diverted at pilots and sensor operator digression in real time during the survey. Any deviation to a flight line will be noted in the DAS field notes.

10.1.3 Flight Line Planning

Proposed flight lines are subject to change at the PIC's discretion due to factors such as weather or obstructions in the terrain.

The Sky HeliMag team is experienced in remote refueling, ‘hot refueling’, and spill avoidance. The standard operating procedures for refueling the aircraft are as follows:

1. Landing Procedures and Safety Protocols

The following safety procedure will be followed during all helicopter ground operations.

- The pilot is in 2-way radio communication with all ground operations.
- During landing and takeoff maneuvers, ground personnel will remain well clear of the aircraft. If proximity to the helicopter is necessary, proper eyewear is required to protect against flying debris caused by rotor downwash.
- Only personnel essential to the survey operation may approach the aircraft.
- Ground support personnel will wear proper Personal Protective Equipment (PPE), including (but not limited to) boots and safety glasses.
- Proper hearing protection is to be worn by personnel working near the aircraft while the engine is running.
- Never approach the rear of the aircraft.
- Never approach or leave the aircraft without the pilot’s knowledge – always approach and leave the aircraft within sight of the pilot.

2. Refueling Procedures

Designated ground personnel will be assigned to support the refueling operations. Helicopter fuel will be stored in tanks stored on a portable platform (truck or otherwise). When the fuel trailer is not in use it will be locked as appropriate.
The following procedure will be followed during all refueling activities:

- Fueling is to be performed by qualified personnel only. Non-qualified personnel must stay clear of the aircraft during fueling operations.
- ‘Hot Refueling’ (i.e. refueling while the aircraft is still running) is authorized where approved and where qualified Sky Research or other qualified refuel personnel are available. All crews and personnel involved in the Hot Refuel procedure must be familiar with the Emergency Aircraft Shut-Down procedure and must be wearing full PPE. The helicopter shall remain running at ground idle with the pilot at the flight controls during all Hot Refuel operations.
- All geophysical survey equipment is to be turned off during fueling operations.
- Helicopter will be electrically bonded to the fueling trailer prior to the beginning of fueling operations.
- Fueling team will consist of two personnel, one trailer pump operator, and one fuel nozzle operator.
- Fueling personnel will wear proper PPE at all times, including but not limited to sturdy boots, safety glasses, hearing protection, and appropriate hand protection.

- A 20 lb B-C class fire extinguisher will be designated for helicopter operations, and will be located with the fuel tanks.
- Fueling personnel will have absorbent diapers available for spill cleanup.

10.1.4 Maintenance Support

Maintenance support will be provided by internal, company, licensed Airframe and Powerplant mechanics with inspection authorization.

10.2 Production Rates

Geophysical mapping production rates are highly variable and depend on several factors, including airspace, topography, vegetation, site access, proximity of survey area, lane spacing, and weather conditions. Typical HeliMag production rates are 350 to 500 acres per day (assuming 8 flying hours/day). Local site conditions such as weather, terrain, and ferry distances are the prime determinants of productivity. Current knowledge of the expected conditions at the proposed site indicates that the productivity should fall within these norms.

10.3 Data Resolution and Density

Data resolution and density will meet Data Quality Objectives (DQOs) defined by the project for spatial registration, down-line and along-line spacing, intrinsic noise levels, and survey velocity. The HeliMag system flies at nominal survey speeds of 15–30 m per second (approximately 30–60 knots). The data processor monitors the data densities and flags any areas for recollection that do not meet the project objectives. When data densities do not meet the objectives, the Airborne Survey Geophysicist will notify the field crew and correct the problem.

10.4 Instrument Validation Survey

An Instrument Validation Survey (IVS) test lane will be established to verify that the system meets the DQOs described in Section 4.4. This test lane will be used for initial instrumentation validation as well as daily monitoring of system performance as described in the Quality Control Plan (Section 4). The validation lane will be nominally 500 m in length. Standardized test items will be placed at intervals along this lane, and their precise ‘ground truth’ locations will be measured using established surveying techniques. The HeliMag detection/location performance will be assessed and monitored by comparison of the system results with the ground truth positions of the test items.

The IVS lane will be comprised of 4 or more inert ordnance items ranging from 2.75” Rockets to 100 lb bombs. At least two of these items will be 155mm projectiles (if available), pointing E-W, and N-S, to provide a test of the system detection performance under these two scenarios. In addition to the standard IVS seed items URS will provide Sky with three ISO for placement in the HeliMag IVS. Upon establishing the validation lane, an as-built map will be prepared to document the surveyed locations of the test items.

10.5 Equipment Warm-Up

Most geophysical instrument readings drift for a couple of minutes after starting up. All sensors will warm up for at least 5 minutes prior to testing or data collection. Each time the instrument starts (e.g., at the start of the day, after breaks, refueling, etc.), this procedure will be followed.

10.6 Record Sensor Position

Proper sensor geometry is important to the spatial registration of data during processing. The sensor positions relative to the helicopter and master GPS antenna are engineered and recorded prior to the survey system installation. These spatial relationships remain fixed. At the beginning of the survey, the SKY field crew will perform a response test under each sensor to ensure that the sensors cables are connected to the appropriate data input channel. This test will be repeated every time the system is disassembled and reassembled.

10.7 Time Alignment Validation

All instruments have a built-in latency between the measurement and the output of the reading. To properly position geophysical data, the time of applicability of the positional data must be aligned with that of the geophysical data. The SKY HeliMag system precisely time stamps all recorded data and the data processing software automatically aligns the data appropriately. The time alignment is verified by collecting data along the validation lane in two reciprocal directions. Proper time alignment is validated by comparison of survey responses from these two reciprocal lines to ensure that the magnetic peaks are aligned. This test is performed at the start and end of each survey day as part of the IVS lane test. If the Airborne Survey Geophysicist or Project Manager terminates field operations early due to weather conditions, the end-of-day test may not be performed. The Validation Lane Survey Log will document the results of this test.

11 Data Processing

SKY uses its custom in-house software called SkyNet to transcribe, filter, decimate, and position the airborne geophysical data. The output from SkyNet is an ASCII xyz file that can then be imported into the Geosoft Oasis Montaj geophysical processing environment. Oasis is used to visualize the data and apply advanced processing where required. Depending upon the anomaly detection methodology, anomaly selections may be performed in the Oasis environment or in the proprietary UXOLab environment. UXOLab is a fully-functional, validated, MATLAB-based data processing package. The anomaly selection environment will depend on whether manual/peak detection or the wavelet detection method will be used. The final decision regarding anomaly selection method will depend upon the site conditions. The following sections describe the processing steps used by SKY as part of the site-specific data processing and analysis. The Data Processing Report documents the parameters used and statistics from the review and processing steps.

11.1 Data Transcription

The raw data are transcribed from their native data file formats into ASCII xyz files using SkyNet. At this point, the geophysical data are subjected to a lowpass/notch filter,

decimated to a sample rate of 100 Hz and assigned 3D positions based upon the GPS master antenna position, aircraft attitude and the system geometry.

11.2 Initial Data Review

The Data Processor performs the initial review of the geophysical data. If problems exist, the Data Processor will notify the Project Geophysicist. The Project Geophysicist will assess the problem(s) and make adjustments to the field operations or data processing as needed to ensure quality data collection. The sections below detail the initial review of each data type.

11.2.1 Geophysical Data

The initial review of geophysical data ensures that the data are within a reasonable range, are free from dropouts/spikes, and timing errors and otherwise appear to be valid. A qualified data processor reviews the summary and visually inspects the data. The Data Processing Report documents any discrepancies.

11.2.2 Positional Data

The initial review of positional data involves checking line profiles for position dropouts/spikes. The Data Processing Report documents any discrepancies.

11.3 Sensor Data Filtering

Spatial and/or time base filters are used to remove long wavelength signals from the dataset. Some of the sources of this long wavelength response are diurnal variations, geologic response, sensor heading errors, and aircraft maneuver noise. The specific parameters of the filters are to be determined by site conditions such as geologic response and survey altitude above ground. Details of all filtering performed will be provided in the Data Processing Report.

11.4 Spike Removal

When data spikes are numerous, this indicates a problem with the instrument. Sporadic data spikes are typical but usually occur infrequently. Running a spike rejection function removes data points that resemble spikes. The Airborne Survey Geophysicist will set the maximum acceptable jump parameter for the spike rejection as part of his review of the processing procedures. Typically, this value is set to 100.

11.5 Gridding Method and Search Criteria

To convert the data into an image map, an interpolation algorithm will convert the XYZ data into an evenly-spaced grid image at 1 m intervals. The data processor will review the grids to determine the completeness and accuracy of prior data manipulation steps.

11.6 Color Distribution Level Selection

The Airborne Survey Geophysicist will select color distribution levels (thresholds, min/max, etc.) that accentuate the areas/anomalies of interest in the anomaly density maps provided for each block. The same color scheme will be used for each block, in order to avoid confusion and to enhance the ability to compare the anomaly densities across the site easily.

11.7 Total Magnetic Field Maps

The final gridded data are an interim product of the HeliMag data processing. In order to aid in visualization of the magnetic response across the site, the gridded data will be presented in map form. The total magnetic field maps will be annotated to contain the following information:

- Site name
- Map product
- Survey location
- Vertical scale bar
- Project coordinate system grid and labels

12 Data Analysis

After processing, anomalies in the final total magnetic field data that are consistent with the magnetic response of MEC (with respect to size, shape, and special extent) are selected. These anomalies are then used as the basis for creation of anomaly density maps. These density maps provide a visual representation of the spatial distribution of detected ferrous metal targets. High density anomaly clusters are identified as areas of interest.

12.1 Anomaly Selection and Decision Criteria

For each dataset, the Airborne Survey Geophysicist will assess each of the following factors prior to generating an anomaly list:

- Geophysical response (amplitude) of targets of interest, as measured in the calibration lane;
- The local geologic/anthropologic background conditions after filtering;

Based upon the site conditions, the Airborne Survey Geophysicist will elect to select anomalies using automated or manual techniques. Under most conditions, automatic picking algorithms perform well. However, in areas with challenging background magnetic response or a great deal of anthropogenic clutter, manual selection techniques are required. When automated techniques are used, a manual review of the data and targets will be used to locate additional anomalies or to delete anomalies. The Data Processor and QC Geophysicist will delete anomalies if they are obviously due to cultural features or are obviously outside of the size/depth/shape envelopes of the targets of interests. Details on the anomaly selection and decision criteria will be provided in the Data Analysis Report.

12.2 Target Analysis/Classification

Each selected anomaly will be analyzed. The target analysis algorithms have been adapted to run within the University of British Columbia MATLAB UXOLab software environment developed specifically to conduct target analysis and picking. Within the analysis environment, the processor selects mapped anomalies interpolated from the magnitude-corrected XYZ sensor data points. The software extracts sensor data points

associated with the selected target. Each sensor reading is an input datum used in a six-parameter, iterative calculation to derive the parameter values that describe a dipole model that best fits the observed data. These parameters include dipole position (3 dimensions), dipole angle (2 angles) and dipole magnitude (size). These derived dipole parameters are then compared to training datasets developed from inert ordnance to perform target classification. Final outputs from this step are XYZ points in ASCII format with associated dipole parameters and target classification declarations.

12.3 Target Density Distribution Analysis

Target density distribution maps will be the final product of the HeliMag data processing. To aid in visualizing the distribution of metallic items across the site, a density raster is computed using a 100 m radius neighborhood kernel that assigns anomaly densities (in anomalies per hectare) to each cell in the raster. The target classification results are used to provide refined target lists and density distributions based upon site-specific goals and conditions.

Although it is not possible to determine which specific anomalies are due to the targets of interest, it is possible to refine the list by excluding some anomalies based upon the character or 'features' of the anomaly. Each anomaly is characterized by performing a dipole fit analysis. A magnetic dipole model can be defined with six parameters. These parameters define the position, the orientation, and the size of the dipole. An iterative process is used to determine the values for these parameters that describe the dipole model that best fits the observed data for each anomaly. These parameters are then used as 'feature' estimates for each target (e.g., the dipole model positions are accurate estimates of the object position and depth of each target). The target list can then be refined by excluding anomalies based upon one or more of these features. Dipole size and orientation with respect to the Earth's field are the most useful features for refining targets lists.

The utility of the dipole orientation relative to the Earth's field is as follows: The magnetic response of ferrous material has two sources, 'induced' magnetism and 'remanent' magnetism. Objects that have undergone mechanical shock (such as ordnance that have been fired) will become demagnetized – i.e., the remanent magnetization is removed. In addition, for ordnance-shaped objects 'induced' magnetic dipoles are aligned within 60 degrees of the Earth's magnetic field vector, while remanent dipole responses are not similarly constrained. Thus targets with dipole orientations greater than 60 degrees from parallel with the Earth's field can be assumed to have significant remanent magnetization and, as such, are not likely to be associated with ordnance usage.

Dipole size is an obvious feature to use to refine the target list. Unfortunately, the dipole fit size estimate for any given object will depend heavily on the orientation of the object in question. Figure 4 presents feasibility curves for a selection of ordnance items listed as possible items of interest. These curves show how the dipole response for any given ordnance item can vary depending upon its physical orientation with respect to the Earth's field. The dipole response is non-unique for any shapes other than a sphere. The maximum moment is achieved when the target is aligned with the Earth's field and the minimum moment is achieved when the target is normal to the Earth's field (note the image in Figure 4 depicts the dipole angle, not the physical angle of the object). It is also

apparent from this image that multiple ordnance types occupy the same spot on the graph, thus they may provide the identical responses. Furthermore, there are an infinite number of non-ordnance ferrous objects whose responses may also overlap with responses of the objects of interest. For this reason, total magnetic field techniques cannot be used to definitively declare an object as ordnance. However, to the extent that a given target response does not come close to the feasibility curves of the objects of interest these features can be used to exclude these targets from the refined target list.

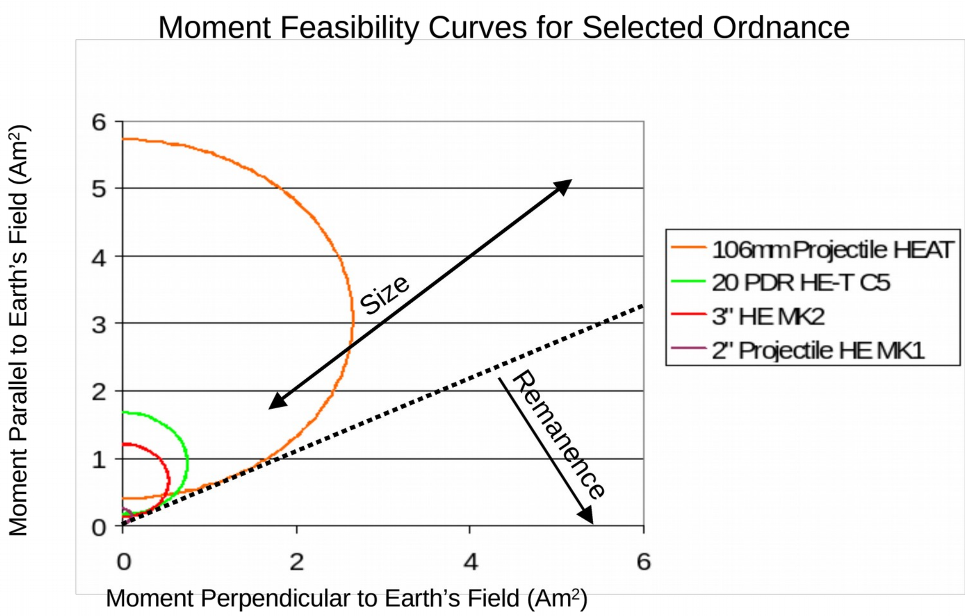

Figure 4. Dipole response feasibility curves. The predicted dipole moment for given ordnance types are plotted relative to the Earth's magnetic field vector. Dipole response angles greater than 60° indicate the presence of remanent magnetization. Note that the dipole angle, although related, is not the physical angle of the object.

12.4 Target Density Distribution Maps

Target density distribution maps are the final product of the HeliMag data processing. In order to aid in visualizing the distribution of metallic items across the site, a density raster will be computed using a 100 m radius neighborhood kernel that assigns anomaly densities in anomalies per hectare to each cell in the raster. The density maps will be annotated to contain the following information:

- Site name
- Map product
- Survey location
- Vertical scale bar
- Project coordinate system grid and labels

In addition to the target density maps, an ASCII listing of the selected targets will be provided. This list will include

- Site name
- Survey location
- Unique anomaly identification numbers
- Anomaly easting and northing in project coordinate system and/or local coordinates
- Selected QC anomalies
- Geophysical data value

13 Data Deliverables

13.1 Quality Control Data Sets

Fully analyzed data from each QC data set will be provided to the URS project geophysicist via the ftp site no later than one working day after data collection each day. QC data set deliverables will include the following:

- Image file (such as a portable document format [pdf]) showing graphical results of each quality control test;
- Geosoft ".xyz" file for each QC set; XYZ data sets will include columns for X, Y, raw data, final data, and any other applicable data;
- Clear accompanying information to determine the contents of each file; and
- Geotiff image of sensor positions (or preliminary sensor data) to show survey coverage.

13.2 Final Data Sets

Fully processed data from each survey and its associated QC data sets will be provided to the URS project geophysicist via ftp site no later than 5 working days after collection of that particular data set is completed. Deliverable will include the following:

- Geosoft ".xyz" file for unit of survey being delivered (such as a grid or area agreed upon with URS Munitions Response geophysicist); XYZ data sets must include columns for X, Y, raw data, final data, and any other applicable data;
- Geosoft ".grd" file for unit of survey being delivered;
- Geosoft ".gdb" file for unit of survey being delivered;
- Geosoft ".map" file for unit of survey being delivered;
- Geosoft mosaic map of all processed data to date; all maps to include titles, scale, north arrow, color scale, index map, legend, creator, and date created; and
- Clear accompanying information to determine the contents of each file.

13.3 Project Documentation

SKY will document all field and data processing activities in the following reports:

Validation Lane Survey Log: This log documents the results from the Daily Validation Lane Flights and QC checks. It will be updated and delivered on a daily basis.

Data Acquisition Log: This log documents information about each survey event and summarizes crew, equipment, filenames, and surveyed areas. It will be updated and delivered on a daily basis. The following will be tracked:

- Date of data collection
- Sortie ID
- Site ID
- Survey line file (track file)
- Survey lines flown
- Name of pilot
- Name of system operator
- Name of ground support technician
- Name of data processor
- Name of project geophysicist
- Field notes (comments)

Data Processing Log: This log documents by sortie the data processing steps performed on each sortie as well as visual and statistical data quality checks. It will be updated and delivered on a daily basis. The tracking sheet will incorporate the sortie tracking information, as well as the processing steps and output as follows:

- Date of data collection
- Sortie ID
- Site ID
- Survey line file (track file)
- Survey lines flown
- Name of pilot
- Name of system operator
- Name of ground support technician
- Name of data processor
- Name of project geophysicist
- Field notes (comments)
- All filtering information (such as De-median or L-pass) and details of the parameters used
- All QC check results (down-line sample density, spike rejection)
- Oasis site database
- Name of grid

- Name of archive

It bears note that the Data Collection Log and the Data Processing Log may be combined into a single excel spreadsheet (Data Collection and Processing Log) to facilitate tracking and reporting of the survey activities.

Data Analysis Report: This report, documents by site the various analysis steps as follows:

- Name of site
- Name of grid
- Name of archive
- All QC check results (altitude performance, survey coverage)
- Anomaly selection method (manual/wavelet/AS peak detection)
- Name of anomaly selection analyst
- Name of anomaly list file
- Name of anomaly QC analyst
- Name of anomaly list after final QC
- Name of analyst performing dipole fit/classification
- Name of dipole fit analysis output file
- Name of anomaly classification output file
- Dipole fit/Classification QC name
- Name of geographic information systems (GIS) analyst
- Name of GIS density map output file
- Density map QC name

It will be updated and delivered at the conclusion of the project.

13.4 FTP Site Requirement

All deliverables will be posted to a mutually agreed upon ftp site to allow access for URS and Sky personnel.

13.5 Aerial Magnetometer Survey Report

After completion of the field investigation and data analysis, an Aerial Magnetometer Survey Report will be prepared.

A general preliminary outline is as follows:

- Table of Contents
- List of Acronyms
- Introduction
  - Background and Project Objectives
  - Scope of Work
  - Site Location and Description

- Equipment
- Methodology
  - AMS Survey Activities
  - Data Processing and Interpretation
- Results
  - Summary of Work Performed
  - Mobilization and Site Setup
  - AMS Survey Activities
  - Data Processing and Interpretation
- Quality Control
  - System Validation
  - AMS Instruments and Positioning System Quality Control
- Conclusions
- References
- Attachments
  - Examples of data deliverables (such as maps and QC results for each type of QC test)
  - E-size mosaic plate(s) showing AMS results
  - E-size mosaic plate(s) showing anomaly selection locations
  - Photographs of AMS equipment and operations
  - Compact Disc (CD) (or digital video disc [DVD]) with all data and deliverables, including a document in pdf describing contents of folders

3.0 QUALITY CONTROL PLAN

14 Introduction

This Quality Control Plan (QCP) describes the QC approach and procedures for the AMS operations. The purpose of this QCP is to ensure that the AMS data collected is appropriate to meet the survey objectives. Challenges for airborne surveys include, intrinsic noise levels, data positioning, and navigation (horizontal and vertical). The DQOs provided in Tables 2 and 3 are designed to ensure that these challenges are met with the rigor required to ensure that the quality of the final data set is sufficient to support the observations and conclusions made in support of the survey objectives. Described in this QCP are the QC organization and responsibilities, initial IVS tests, and QC of production survey data acquisition.

15 QC Organization and Responsibilities

This subsection identifies QC responsibilities associated with key members of the QC organization and describes communication procedures that will be followed throughout AMS operations. Table 2 lists the key project personnel and associated contact information.

Table 2. Key Personnel Contact Information

Name	Role	Address	Phone	email
Stephen Billings	Program Manager	Sky Research, Inc. 112A, 2386 East Mall Phone: 541.552.5185 Vancouver, BC, V6T-1Z3 CANADA Fax: 604.827.3221	541.552.5185 (office) 604.506.9206 (mobile)	steve.billings@skyresearch.com
John Steinbergs	Project Manager	Sky Research, Inc. 445 Dead Indian Memorial Rd. Ashland, OR 97520	541.552.5128 (office) 541.941.8559 (mobile)	john.steinbergs@skyresearch.com
David Wright	QC Geophysicist/ Technical Support	Wright Research and Design 9500 Kingsford Dr. Cary, NC 27518	919.520.8673	david.wright@wrandd.com

Name	Role	Address	Phone	email
Raul Fonda	AMS Geophysicist/ Field Operations	Sky Research, Inc. 12850 E Control Tower Rd Centennial, CO 80112	541.552.5121 (office) 541.261.1143 (mobile)	raul.fonda@skyresearch.com
Sue Hawkins	Contract Administration	Sky Research, Inc. 445 Dead Indian Memorial Rd. Ashland, OR 97520	541.552.5105 (office) 541.840.3465 (mobile)	sue.hawkins@skyresearch.com

15.1 Key QC Personnel

The organizational structure and responsibilities of the SKY AMS team is designed to provide comprehensive QC for the project. Selected positions with primary QC responsibilities are described in the following paragraphs.

15.1.1 Sky Research Project Manager

The Project Manager is responsible for overall project activities, including cost control, schedule control, and technical quality. The project manager has ultimate responsibility within the project team for producing deliverables that are technically adequate, satisfactory to the client, and cost effective. To accomplish this, the project manager develops an internal project review schedule and monitors budgets and schedules. The project manager will work with the project team to select an internal QC review team, to coordinate review efforts, and to address review comments.

15.1.2 Sky Research AMS Geophysicist

The SKY AMS Geophysicist reports to the project manager and is responsible for coordinating overall field efforts. As the lead SKY field representative, he is also responsible for ensuring that field activities are performed in accordance with approved Work Plans, policies, and field procedures. The SKY AMS Geophysicist is responsible for implementing and administering field aspects of the project QCP and communicating the onsite QC program policies, objectives, and procedures to the project personnel during project meetings and informal discussions.

15.1.3 Sky Research QC Geophysicist

The SKY QC geophysicist is responsible for reviewing AMS data, ensuring all QC tests have been performed and data pass DQOs and QC criteria, and deliverables are prepared as specified in project documents. The SKY QC geophysicist approves all data deliverables for delivery and certifies that appropriate QC has been performed on the data prior to delivery and adjudicates all technical issues.

15.1.4 Pilot in Command

The PIC is responsible for flying the helicopter in a safe efficient manner. The PIC makes all final decisions that affect the safety of the aircraft and crew, including survey flight parameters (speed, altitude) and work stoppages due to weather conditions. Gaps in coverage due to terrain/obstacle avoidance are allowable at the PIC's judgment.

15.2 Project Communication

One of the most critical elements in performing any type of project is to establish and maintain lines of communication among all project personnel. At the beginning of the project, the Project Manager will prepare written project instructions that will be distributed to all team members. These instructions will document project and task instructions, and each team member's responsibility in achieving the objectives, as well as a budget and schedule for successfully executing the work.

Before field activity begins, a project team meeting will be conducted to review the concept, assumptions, objectives of the field approach, and project objectives. During the field investigation phase of the project, the field teams will meet daily to review the status of the project and to discuss technical and safety issues. When necessary, other meetings will be scheduled, or the site manager will meet individually with field personnel, to resolve problems.

During the field effort, the site manager will be in regular telephone or face-to-face contact with the project team. When significant problems or decisions requiring additional authority occur, the site manager can immediately contact the Project Manager for assistance.

16 Instrument Validation Survey

Prior to commencement of data acquisition an Instrument Validation Survey (IVS) will be performed. The primary objective of the IVS will be to document the site-specific capabilities of the HeliMag system to operate as an integrated system capable of meeting project DQOs and to validate that the specific system to be used is functional and operating within industry standards. For the purposes of the IVS tests, a system is considered to include the survey platform, sensors, navigation equipment, data analysis and management, and associated equipment and personnel. The technologies to be tested are the component technologies listed previously, with the seven magnetometers configured at 1.5 m spacing. The IVS will be seeded by Sky Research with inert items or stimulants (in consultation with URS personnel). The HeliMag operations geophysical team will begin surveys of the IVS once mobilization is complete.

The survey altitude is a critical parameter for this type of investigation as the ability to detect objects of a given size is dependent upon the survey altitude above the object. Therefore, the objective for the HeliMag data collection is to maintain a safe altitude while still supporting a significant level of detection. Under ideal topographic and vegetation conditions, survey data are collected at a nominal sensor altitude of 1.5 to 3 m AGL. However, the conditions at portions of the proposed survey site are less than ideal due to the presence of significant vegetative cover and deeper water. The detection capability of the HeliMag system at altitudes up to 5 m, will be evaluated using the results of the IVS. The IVS will be flown at multiple altitudes from the lowest the system

can safely fly to approximately 5 m AGL at approximately 1 m increments for comparison and analysis purposes.

The IVS objectives will be attained through evaluation of the achievement of the DQOs (as provided in Table 3), and review of previous industry experience with the geophysical instruments considered.

Table 3. Proposed Data Quality Objectives for Instrument Validation Surveys

Data Quality Objective	Measurement Performance Criteria	Evaluation Method During IVS
Accurate coordinates are being obtained from positioning systems.	Positional error of targets emplaced in a validation lane will not exceed ±50 cm.	Review of low altitude validation flight data analysis results for emplaced targets.
Repeatable data are being obtained from system.	Derived target size and dipole angle of repeated surveys will be consistent to within 20% and 20° respectively.	Review of validation flight data analysis results.
Ordnance detection: survey system response is comparable to expected response of geophysical instrument.	Sensor response over specific items to be compared to response of geophysical instrument over similar items under previous test or field production conditions.	Verify that system response is comparable to response expected through previously documented instrument capabilities.
Down-line data density is sufficient to detect MEC items.	Over 98% of possible sensor readings are captured along a line spacing of no greater than 0.4 m between points.	Results of HeliMag surveys will be evaluated to ensure compliance.
Coverage over survey area is sufficient to detect MEC items.	Flight line gaps not to exceed 2.5 m over the emplaced anomalies.	Results of HeliMag surveys will be evaluated to ensure compliance.
Survey altitude is sufficient to meet goals of IVS.	Data are collected in separate passes at nominal 1m intervals from 2 – 5 m AGL.	Sufficient passes must be performed along this range of altitudes to allow prediction of maximum survey

Data Quality Objective	Measurement Performance Criteria	Evaluation Method During IVS
		altitude for reliable detection of given ordnance items.
Intrinsic noise	Below 1 nT.	Results of data collected at high altitude out of ground effect will be evaluated to ensure compliance.
Data Handling		
All data must be delivered in a timely manner and in a useable format.	Quality Control Data Sets are completed and uploaded to the project ftp site within 1 working day of data collection and Final Data Sets within *5* working days of data collection.	Evaluate based on actual delivery of data.

17 Production Survey Data Quality Objectives

During the survey data acquisition phase of this project, system functionality, survey acquisition parameters, and data delivery time objectives will be monitored. The DQOs for this phase of the project are provided in Table 4 below. A more detailed discussion of the DQOs is provided below.

Table 4. Proposed Data Quality Objectives for Aerial Magnetometry Production Surveys

Data Quality Objective	Measurement Performance Criteria	Evaluation Method During Production Survey
General System Functionality		
Accurate coordinates are being obtained from positioning systems.	Positional error of targets emplaced in a validation lane (flown twice daily) will not exceed ±50 cm.	Daily review of validation flight data analysis results.
Repeatable data are being obtained from system.	Derived target size and dipole angle will be consistent to within 20% and 20° respectively (for validation line data collected daily)	Daily review of validation flight data analysis results.

Data Quality Objective	Measurement Performance Criteria	Evaluation Method During Production Survey
Ordnance detection: survey system response is comparable to expected response of geophysical instrument.	Sensor response over specific items to be compared to response of geophysical instrument over similar items under previous test or field production conditions.	Verify that system response is comparable to response expected through previously documented instrument capabilities.
Survey Data Acquisition		
Down-line data density is sufficient to detect MEC items.	Over 98% of possible sensor readings are captured along a line spacing of no greater than 0.4 m between points.	Results of HeliMag surveys will be evaluated to ensure compliance. Gaps due to obstacle/terrain avoidance consistent with the safety of aircraft and crew are acceptable and will not be cause for re-flights.
Coverage over survey area is sufficient to detect MEC items.	Flight line gaps not to exceed 2.5 m for distances > 500 m.	Results of HeliMag surveys will be evaluated to ensure compliance. Gaps due to obstacle/terrain avoidance consistent with the safety of aircraft and crew are acceptable and will not be cause for re-flights.
Survey altitude is sufficient to meet declared detection goals	80% of the sensor readings will be collected within 3 m of (or below) the vegetation canopy/terrain	Survey altitude will be monitored in the database. For those regions where the top of the canopy cannot be verified digitally, anecdotal reports from the pilot will be deemed as sufficient to meet this DQO. Note discussion points in accompanying text.
Intrinsic noise	Below 1 nT	Results of data collected at high altitude out of ground effect will be evaluated to ensure compliance.
Data Handling		
All data must be delivered in a timely manner and in a useable format.	Quality Control Data Sets are completed and uploaded to the project ftp site within 1 working day of data collection and Final Data Sets within *5* working days of data collection.	Evaluate based on actual delivery of data.

Positioning Accuracy: HeliMag data are positioned to better than 0.1 m. However, verification of this level of accuracy for a dynamic system is difficult. For this reason we verify position accuracy though the use of seeded targets. The measurement performance criterion for this is that the positional error at known monuments emplaced in a validation lane (flown twice daily) will not exceed ±50 cm. This will be evaluated by ensuring that dipole fit analyses results for emplaced targets meet this criterion.

System Repeatability: The DQO for HeliMag systems data repeatability is that the systems respond consistently from the beginning to the end of an operation. As with the positioning accuracy DQO, determining repeatability with a dynamic system where the target/sensor separation distance varies from pass to pass is very difficult. However we can use the consistency of the emplaced target dipole fit results to indicate that the system performance is stable. The measurement performance criterion for this is that the derived target size and dipole angle will be consistent to within 20% and 20° respectively (for validation line data collected daily).

System Response: The DQO for system response is to detect items comparably to what would be expected through either documented instrument tests or instrument response models for the instrument being validated. The focus of the analysis for detection is concentrated on determining that the geophysical instrument and the system as a whole is functioning as designed at the particular location.

Down-Line Data Density: The DQO for down-line (along the survey transect) data density is to have sufficient data collected along each transect to detect targets. The measurement performance criterion for this is that at least 98 percent of possible sensor readings are captured along each transect at 0.4 m or less. Results of HeliMag surveys will be evaluated to ensure compliance. Gaps due to obstacle/terrain/vegetation avoidance consistent with the safety of aircraft and crew are acceptable and will not be cause for re-flights. The purpose of this metric is to assure sufficient down-line sample density to achieve our detection goals for areas covered by the HeliMag system. Final survey coverage is verified using the following Survey Coverage DQO.

Survey Coverage: The DQO for lane spacing is to maintain appropriate lane spacing to provide 100 percent coverage of the survey area. The measurement performance criterion for this is that the lane spacing variation results in gaps no greater than 2.5 m for distances greater than 500 m. Results of the HeliMag surveys will be evaluated to ensure compliance. Gaps due to obstacle/terrain /vegetation avoidance consistent with the safety of aircraft and crew are acceptable and will not be cause for re-flights. If logistic considerations prevent full RTK GPS coverage, a decision will be made, in consultation with URS personnel regarding allowable gaps and mitigating actions. This eventuality is not likely and all reasonable efforts to obtain full RTK GPS coverage will be made by Sky Research.

Survey Altitude: Survey altitude is the prime determinant of signal strength. Thus, provided the intrinsic system noise is below a reasonable level, survey altitude is a prime determinant of detection performance. Over a portion of the proposed survey site, vegetation will prohibit maintaining consistent survey altitudes within the standard operating altitude range of 3 m AGL or lower. Safety of the aircraft and crew is paramount, and the decisions of the PIC with respect to survey altitude and

terrain/obstacle avoidance are final. Consequently, derivation of a meaningful, enforceable DQO for survey altitude is somewhat complicated. Although, ideally all survey data would be collected below 3 m AGL, this is obviously not possible, thus it would not be enforceable. As a compromise, the survey altitude performance will be verified with digital data where possible. Where this is not possible (e.g. area with variable vegetation) the PIC's final judgment with respect to achievable survey altitude will be deemed as sufficient to meet this DQO.

Intrinsic Noise: The DQO for intrinsic noise is not more than 1 nT. The intrinsic noise value is considered accumulated noise from sensors and sensor platforms, including GPS, rotor noise, radio frequencies, etc., calculated as the standard deviation of a 20 second window of processed data collected out of ground effect. Results of the HeliMag surveys will be evaluated to ensure compliance.

Data Delivery: The DQO for data delivery is that all data must be delivered in a timely manner and in a useable format; the QC data sets must be completed and uploaded to the project ftp site within 1 working day of data collection and final Data Sets within 5 working days of data collection.

18 Definable Features of Work

Definable features of work (DFOW) are used to enable audit of the project progress. The DFOW specific to the AMS operations are summarized in Table 5.

Table 5. Definable Features of Work, Auditable Functions, and Responsibilities – Aerial Magnetometer Surveys

Definable Feature of Work with Auditable Function	Responsible Person(s)[a]	Audit Procedure	Freq. of Audit	Pass/Fail Criteria	Action if Failure Occurs
IVS Execution	Sky QC Geophysicist	Verify DQOs established in IVS Work Plan have been accomplished.	O	DQOs identified in IVS Work Plan have been achieved	Continue with IVS until DQOs are achieved.
AMS Survey	Sky Geophysicist	Verify AMS Survey conducted IAW AMSWP.	O/D	Data collection conducted IAW Wide Area Assessment Investigation Plan	Stop activity until full compliance can be assured and any activities not performed within compliance are re-evaluated and re-performed if necessary.
AMS Survey	Sky QC Geophysicist	Check results of QC tests performed as specified in AMSWP.	E	QC tests must pass IAW standards determined during the IVS and referenced SOPs.	If a QC test does not pass, a root-cause analysis must be performed, and the project team must meet to discuss and determine appropriate action.
AMS Survey	Sky QC Geophysicist	Confirm that data collection DQOs established during IVS are being achieved.	E	Data collection DQOs are being achieved.	If the DQOs are not being achieved, a root-cause analysis must be performed, and the project team must meet to discuss and determine appropriate action.
AMS Data Processing	Sky Geophysicist	Verify data checks specified in AMSWP.	E	Data checks must pass in accordance with standards determined during the IVS and referenced SOPs.	If a QC test does not pass, a root-cause analysis must be performed and the project team must meet to discuss and determine appropriate action.

IAW = in accordance with Frequency: O = Once D = Daily E = Each occurrence

4.0 HEALTH AND SAFETY PLAN

19 Introduction

This HASP establishes general and site-specific health and safety requirements specific to the planned airborne geophysical survey utilizing helicopter magnetics (HeliMag) in support of Active Army Military Munitions Response Program Field Demonstration of Wide Area Assessment Methods at Closed Castner Firing Range, Fort Bliss.

SKY will be performing low altitude airborne magnetic surveys at the site. This HASP will address general aviation safety measures, guidelines for conducting survey operations, potential hazards associated with aircraft operations and ground support, and emergency response procedures. As in all airborne operations, final decisions regarding safety of the aircraft, crew and passengers are the responsibility of the aircraft operator and the pilot in command. In addition, compliance with the Federal Aviation Administration (FAA) regulations and standards for civilian aircraft operations, and FAA approved aircraft specific maintenance procedures and flight manuals are mandatory.

Because not every health and safety hazard encountered in the field can be anticipated, field personnel must be equipped and trained to recognize and respond to unforeseen hazards. Above all, employees must maintain a high level of safety awareness and exercise common sense and good judgment when confronted with a hazardous or unsafe situation.

All personnel and visitors involved with SKY activities at the site are expected to read and abide by all provisions of this HASP. All personnel participating in on-site activities will sign a document stating that they have read, understand, and will abide with the requirements of the HASP. This HASP provides guidelines to protect personnel, the public, property, and the environment from hazards associated with site activities and potential site contaminants.

20 Aircraft Operations

The following are general guidelines for performing airborne survey operations.

20.1 Aircraft Ground Support Operations

- Daily inspections and preflight inspections of aircraft and equipment installations will be performed pursuant to manufacturer’s specifications.
- Flight plans are to be filed as appropriate. Where flight plans are required by local authorities, a company flight plan will be made and monitored.
- Preflight briefings are to be performed prior to each survey flight. Ground crew must be aware of planned flight activities, fuel reserves, and estimated return times.
- Weight and balance calculations must be performed after any modification to the aircraft, including initial installation of any survey equipment.
- Daily weather forecasts are to be obtained prior to commencement of survey operations.
- Site-specific hazards will be addressed prior to commencement of survey operations.

- Ground support personnel will wear proper Personal Protective Equipment (PPE).
- During landing and takeoff maneuvers, ground personnel will remain well clear of the aircraft.
- Never approach or leave the aircraft without the pilot's knowledge – always approach and leave the aircraft within sight of the pilot.
- Fueling is to be performed by qualified personnel only. Non-qualified personnel must stay clear of the aircraft during fueling operations.
- The aircraft must be grounded prior to fueling operations.
- Fueling personnel will have absorbent diapers available for spill cleanup.

20.2 Airborne Operations

- The PIC has complete jurisdiction over all aircraft related operations, emergency response activities and requirements.
- No aircrew member will fly while under the influence of substances, including alcohol and illegal, prescription, or over the counter drugs, which may impair physical or mental acuity.
- The aircraft operator shall maintain up to date insurance.
- Only necessary personnel are permitted on board during flight operations.
- The PIC has the authority to abort any flight for safety considerations.
- The PIC may deviate from survey specifications (speed, altitude and/or flight duration) for safety considerations.
- Over-flight of restricted areas may only be performed with authorization from the appropriate authorities.
- The pilot is in 2-way radio communication with ground personnel (if necessary or required).

21 Emergency Response Procedures (Airborne Operations)

These site-specific emergency response procedures are intended to provide a preplanned course of action to cover aircraft-related emergencies during survey operations. A list of contact numbers and pertinent information will be maintained at the base of operations. All actions will be initiated by the Project Manager on-site. Conditions resulting in the invocation of these procedures are defined as Alert Levels I, II, or III. Definitions of each Alert Level and appropriate responses are provided as follows:

Level I - Overdue Aircraft:

<u>Initiated by</u>:

- A missed scheduled radio report or estimated time of arrival (ETA) by ten minutes.

<u>Objective:</u>

- To ascertain if delays in reporting or arrival are due to communication difficulties, or diversion of aircraft due to weather or in-flight problems.

<u>Action</u>:

- Request a communication search from local air traffic control (ATC) authorities.
- Prepare for a ground search (where feasible).

- Take appropriate action, including progression to Alert Level II.
- Begin log of actions and timelines.

Level II – Missing Aircraft:

Initiated by:
- Missed scheduled radio report by 30 minutes.
- Missed ETA by 20 minutes.
- Receipt of radio report of problems in flight.
- Failure to return after fuel supply including reserves is exhausted.

Objective:
- Ascertain if the aircraft has landed at an alternate location.

Action:
- Advise ATC and request action plan to be initiated.
- Call local Search and Rescue (SAR) or emergency response teams and advise of overdue aircraft.
- Perform ground search of alternate landing sites.
- Take appropriate action, including progression to Alert Level III.
- Update log of actions and timelines.

Level III – Missing Aircraft Presumed to Have Crashed:

Initiated by:
- Receipt of a MAYDAY, SOS, or ELT signal from the aircraft, or ground.
- Report of a distressed or downed aircraft.
- Missed ETA by 30 minutes and failure to make radio or visual contact at alternate landing sites.

Objectives:
- Locate downed aircraft as quickly as possible, ascertain medical requirements, and dispatch immediate medical help.

Action:
- Provide location information (including last known position, and planned flight activities) as well as all pertinent flight plan information (helicopter type, registration, number of passengers) to SAR personnel.
- When aircraft is located, note time, specific location, condition of crew and conditions around crash site including nearest landing zone and ground access routes.
- Advise and update appropriate emergency personnel (local police, ambulance, fire department, ATC). Transfer command to trained SAR personnel (civil or military) at earliest possible time without compromising the above-mentioned objectives.
- Continue detailed log of actions and timelines.

22 Ground Support Operations

22.1 Ground Support Field Tasks

Ground support field operations are summarized as follows:

- Pre-flight site visits
- Field oversight activities, including coordinating and managing site preparation operations
- Emplacement of ground survey targets and fiducials
- GPS base station operation
- Field calibrations (record basic site information, photos, RTK GPS coordinates, feature measurements)
- Provide first aid kits and fire extinguishers for use at the field work sites and vehicles
- Provide basic first aid to injuries until emergency response personnel arrive

The sections below evaluate information on UXO hazards likely to be encountered, as well as physical and biological hazards at the site. The potential of these hazards to affect the field activities is also discussed.

22.2 Unexploded Ordnance

Many of the airborne investigation survey areas have not been surface cleared of UXO. UXO avoidance procedures will be followed at all times on-site while providing ground support.

22.3 Motor Vehicles

All SKY personnel operating company owned, leased or rented motor vehicles on site will hold a valid driver’s license and comply with local, state and federal traffic regulations. Personnel will perform vehicle safety inspections daily. All personnel will drive defensively and wear seat belts while vehicles are in motion.

22.4 Physical Hazards

Personnel may be exposed to physical hazards, such as severe heat stress; excessive noise levels; and slip, trip, and fall hazards. Engineering controls will be used whenever possible to control physical hazards. Personnel will also use appropriate PPE to minimize exposure to these hazards.

In the event of severe weather, site activities will cease until the field team leader has determined that it is safe to resume operations. Severe weather will include any type of climatic anomaly that presents additional, uncontrollable risk to personnel health and safety.

To prevent heat or cold stress problems, the field team leader will closely monitor personnel working in extremely hot, wet, or cold weather. If conditions become extreme, personnel will be given breaks to reduce the likelihood of heat or cold stress.

Excessive noise levels may be generated from field equipment, aircraft, and other heavy equipment. The field team leader will qualitatively monitor noise levels and will require site personnel to wear hearing protection whenever noise levels are perceived to be dangerous.

Noise control measures will include the following:

- Providing protection against noise exposure for all site personnel when necessary. Action levels will be based on the US Army Corps of Engineers (USACE) Safety and Health Requirements Manual (EM 385-1-1), Section 23, Noise Control, and regulatory requirements established by the Occupational Safety and Health Administration (OSHA).
- Using feasible engineering or administrative controls, whenever noise levels exceed specified limits. According to OSHA regulations, the action level for 8-hour exposures is 85 decibels on the A scale (dBA), measured using the slow response mode. According to the USACE Safety and Health Requirements Manual, permissible noise exposure for 8 hours is 90 dBA. For this project, the 85 dBA limit will be used.

Other physical hazards associated with the site may include the following:

- Uneven terrain and heavily vegetated areas
- Sun exposure
- Vehicle traffic

22.5 Biological Hazards

Biological hazards include animal bites or stings that may cause localized swelling, itching, and minor pain and can be handled by basic first aid treatment. The bites of certain snakes, lizards, and spiders may contain sufficient poison to warrant medical attention. In addition, ticks can spread Rocky Mountain spotted fever and Lyme disease; dogs, skunks, foxes, and other small mammals can spread rabies; and mosquitoes can spread West Nile and encephalitis viruses.

Bee and wasp stings, spider bites, and other insect bites may cause allergic reactions. Anaphylactic shock from stings can lead to severe reactions in the circulatory, respiratory, and central nervous systems of an allergic person and can cause death in severe cases. Personnel assigned to this project who are allergic to insects will be required to carry their prescribed treatment and will notify the field team leader of the nature of any allergies or health problems, as well as the location of medications. All stings or bites will be taken seriously. Personnel stung or bitten will be required to stop work and will be observed for signs of severe swelling, shortness of breath, nausea, or shock. Medical attention will be obtained immediately if any of these symptoms appear. To prevent exposure to insect bites, site personnel will use insect repellents as appropriate. A first aid kit available on site will contain the necessary supplies to treat bites, stings, and other minor injuries. All on-site personnel will be knowledgeable in standard first aid procedures.

23 Site Control

Tasks associated with the site activities involve work in areas where hazardous substances or UXO could be present. However, if unexpected hazards are encountered in work areas, the field team leader will contact the appropriate authorities. If appropriate, barrier tape or traffic cones will designate the hazard zone. Access to a contaminated exclusion zone will be restricted to authorized personnel.

The field team leader will identify routes and areas that personnel are authorized to enter. The following sections discuss site access communications, the buddy system, safe work practices, and HASP enforcement as site control measures.

23.1 Site Access

In general, site access is not required to perform a HeliMag investigation. If access becomes required, Sky personnel will coordinate any access with the URS representative on site.

23.2 Communications

Successful communication between field teams and among field personnel is essential. The following communication systems, when appropriate, will be used during field activities:

- Cellular telephones
- Hand signals
- Field Radios

Field Radios or Cellular telephones will be used to communicate with parties outside of voice contact range and for emergency situations.

Hand signals may be used to supplement voice communication. The following standard hand signals will be used in case of radio communications failure or for emergency onsite communication:

• Both hands on waist	Return to support zone immediately
• Hands on top of head	Need assistance
• Thumbs down	Negative; no
• Thumbs up	Positive; yes; I'm all right
• Fist raised above head-level	Stop

A list of emergency and installation telephone numbers for each site is provided in Table 5 (Section 5.15.2). This list will be kept, with a map of the medical evacuation route(s), in all vehicles during site activities.

23.3 Buddy System

Personnel will use the buddy system during all on-site activities. The buddy system requires that two people work as a team, each looking out for the other. Buddies must maintain continuous line-of-sight contact with one another and be in a position to physically assist each other if assistance is necessary. Personnel will not be allowed to enter the site alone; a buddy must accompany each person. In emergency situations, personnel will evacuate the site using predetermined egress routes.

24 Safe Work Practices

Experience indicates that individuals working at UXO-contaminated sites are tempted to collect souvenirs while on site. Souvenir hunting while on the site is expressly prohibited.

Anyone observed picking foreign objects off the ground will be immediately expelled from the site. Even ordnance that is marked as inert may contain explosive charges in the fuses, unburned propellant, or other hazards.

Other general safe work practices for site operations include the following:

- All site operations will be discontinued immediately if an unforeseen hazardous condition develops.
- Only personnel and equipment needed to perform the required tasks will be permitted on the site.
- Matches, lighters, and other spark- or flame-producing devices are prohibited on the sites.
- Site operations will cease immediately upon the approach of an electrical storm or other severe weather conditions.
- If a fire occurs that may involve explosive materials, all personnel will immediately evacuate to the previously designated safe area using predetermined routes.
- Consumption of alcoholic beverages onsite is prohibited. Personnel having consumed alcoholic beverages during lunch or other breaks will not be allowed on-site.
- Effects of extreme climate conditions should be closely monitored during hot periods and all personnel should be aware of the symptoms and effects of heat stress, heat exhaustion, and heat stroke.

Workers will be aware of any potential trip and fall hazards. Whenever possible, trip and fall hazards will be eliminated or clearly identified with yellow caution tape. Site activities will proceed with caution in any area where the presence of utility lines (such as gas, telephone, and other lines) is known or suspected.

25 Emergency Contingency Planning

The field team leader and site manager will be notified of any onsite emergencies, and will be responsible for ensuring that appropriate emergency procedures are followed. A list of emergency telephone numbers and directions to the nearest hospital will be available on-site. Hospital route maps will be kept in all site vehicles. These emergency procedures will be coordinated with the installation's emergency response procedures before site work begins. PPE, emergency chain of command, evacuation procedures, emergency equipment, and emergency procedures are described in the following sections.

26 Personal Protective Equipment

Site personnel will wear long pants, ankle-high boots, safety glasses and gloves. If heavy machinery is in use, hard hats must be worn. If hardhats are to be worn in UXO areas, then they will be firmly attached to the head of the wearer.

Other PPE at the site will be discussed during the introductory safety, health, and emergency response briefing. The field team leader will also discuss site- and weather-specific PPE for the site activities as needed.

If unexpected hazardous substances or respiratory hazards are encountered, operations will cease.

27 Emergency Chain of Command

A clear chain of command in emergency situations will ensure clear and consistent communications among site personnel and will result in a more effective emergency response. The field team leader will direct SKY emergency response operations and designate duties to other site personnel. The field team leader will make initial contact with off-site emergency response teams (such as first aid, fire, or police); stop work if necessary; and provide for on-site first aid and rescue. SKY personnel will escort the off-site medical team to the emergency site.

28 Evacuation Procedures

If required, personnel will evacuate work sites along access paths designated before the field activities begin. In most cases, this access path will be the most direct path to a designated safe area such as a road or site trailer. During evacuation, equipment will be placed so as not to impede emergency escape and evacuation along cleared paths.

29 Emergency Equipment

At a minimum, the following emergency equipment will be present in each vehicle and on site:

- First aid kit
- Multipurpose fire extinguisher
- Cellular telephone
- Field Radio

30 Emergency Procedures

Procedures for specific types of emergencies are outlined in the following sections; these emergencies include explosion and fires, chemical spills, and injuries or medical emergencies.

30.1 Explosion and Fires

In the event of an unplanned explosion or fire, personnel in the area of the explosion or fire should check to ensure that no personnel were harmed. In the case of such an event, personnel should evacuate the site along designated access paths. Personnel evacuating the site should notify the site manager using cell phones or radio as soon as practical, preferably while evacuating the site.

If personnel are injured, other personnel in the area should assess the situation and notify the site manager by cell phone or radio. If imminent danger does not appear to be a risk, all personnel should stay with injured parties and render first aid support. Otherwise, the injured party should be evacuated from the area along the designated access paths, unless moving the injured party would complicate the injury drastically. SKY personnel will notify the appropriate volunteer fire department or emergency response team.

If personnel are injured, the onsite personnel will escort the volunteer fire department or emergency response team across the site using the shortest linear distance to the injured party from the access road. While the volunteer fire department or emergency response team is assisting the injured party, other personnel will be escorted off the site.

The field team leader will witness the evacuation procedures and conduct a head count of all personnel. The team leader will then notify the volunteer fire department and emergency response team and will act as the onsite incident commander until the volunteer fire department or emergency response team arrives to assume incident command duties. When the volunteer fire department or emergency response team arrives on site, onsite personnel will advise the responding crew chief of the location, nature, and identification of the explosion or fire.

Site personnel should perform the following procedures if they do not endanger personnel or equipment:

- Use an onsite fire extinguisher to control or extinguish any small, localized fires
- Remove or isolate flammable or other hazardous materials that may contribute to fires
- Designate personnel to direct the volunteer fire department or emergency response team
- Warn all occupants of any burning buildings to immediately evacuate
- Close windows, skylights, and doors to any burning buildings but do not lock

30.2 Injuries, Fire, or Medical Emergencies

In the event of an injury, fire, or medical emergency, qualified personnel should provide first aid, if required, and should contact the local volunteer fire department or emergency response team for assistance by dialing 911 on the telephone. In general, injured persons should not be moved except by medical emergency response personnel. However, *if* it is clearly safe to do so and will prevent no further injury, on-site personnel may transport injured persons to the nearest hospital.

UXO-related injuries may include traumatic amputation, bleeding, burns, concussion, shock, and death. If personnel are injured as a result of any emergency, UXO-related or otherwise, those personnel should be treated in accordance with emergency first-aid procedures until qualified medical help arrives on site.

If a chemical brought on site by a contractor causes the injury, personnel should use the first aid procedures outlined in the material safety data sheet for the chemical. Other chemical injuries are not anticipated.

31 Environmental Monitoring

The field team leader will observe personnel for signs of temperature stress and will monitor meteorological conditions during all field activities to ensure the safety and health of personnel as well as site visitors.

31.1 Temperature and Stress Protection Program

Heat and cold stress are serious conditions commonly encountered during fieldwork. The likelihood of a temperature-related illness depends on factors such as level of physical activity, clothing, wind, humidity, working and living conditions, and an individual’s age and state of health. Although OSHA does not have regulations to limit temperature exposures, personnel working on this project will follow guidelines from the American

Red Cross and the American Conference of Governmental Industrial Hygienists. This section discusses heat and cold stress and presents temperature stress guidelines.

Temperature stress will be reduced by using engineering controls, safe work practices, and management techniques. Field personnel will have been trained to recognize and respond to temperature-related illnesses as part of OSHA refresher training, cardiopulmonary resuscitation training and first aid training. Field workers should monitor themselves and coworkers for signs of temperature-related illnesses. The field team leader is responsible for initiating rest schedules during fieldwork.

31.1.1 Heat Stress

The possibility of a heat-related injury during fieldwork is significant because some types of PPE increase the body's workload and decrease the body's means of cooling. Heat stress symptoms include heat cramps, heat exhaustion, and heat stroke. Heat stroke is the most serious condition and can be life-threatening. Control actions and rest schedules that may be used to prevent heat stress are provided below.

Depending on the degree and nature of possible heat stress, the field team leader will choose from the following heat stress control actions:

- Provide adequate liquids to replace lost body fluids. These liquids may be water, powdered commercial rehydrating mixes combined with water, or rehydrating commercial liquids (such as Gatorade®).
- Establish a work regimen that will provide adequate rest periods for cooling down. This action may require additional work shifts or earlier or later work schedules to avoid midday heat.
- Provide cooling devices, such as vortex tubes or cooling vests, to be worn beneath protective garments
- Require the removal of impermeable protective garments during rest periods
- Ensure that all rest periods are taken in a shaded rest area, if possible
- Regulate rest periods and ensure that workers will not be assigned other tasks during rest periods
- Notify all workers of health hazards and the importance of adequate rest, acclimatization, and proper diet
- Instruct workers how to recognize heat stress and to conduct first aid to prevent heat stress

SKY will use physiological monitoring to evaluate each individual's response to heat stress when ambient temperatures exceed 70° Fahrenheit (F) and impermeable garments are worn. Two physiological parameters that may be monitored by the field team leader are Heart Rate and Body Temperature. If the heart rate of any individual exceeds 100 beats per minute at the beginning of any rest period then the work cycle will be decreased by one-third. If the body temperature exceeds 99.6° F at the beginning of any rest period, then the work cycle will be decreased by one-third. The rest period will remain the same.

Higher heat exposures than those shown above are permissible if workers have been undergoing on-site medical surveillance and if it has been established that they are more tolerant of hot weather work than average workers. Workers should not be permitted to

continue work when deep body temperatures exceed 100.4° F as determined through on-site medical surveillance.

All persons working at the installation should be acclimatized to local ambient temperature extremes before conducting heavy work. Personnel will be required to slow their work pace as ambient temperatures rise. Field personnel should increase their salt intake at meals to help prevent heat-related injuries.

Solar heat load and glare from sunlight are also major concerns. Adequate skin covering will be required and may include long-sleeved shirts, trousers, hats, sunglasses, and sun block on exposed skin surfaces. Clothing must be light and loose to allow for air circulation and cooling.

Personnel should memorize and learn to recognize the following heat-related injuries:

- Heat cramps. Primary symptom is cramping of muscles. Victims should rest in the shade and rehydrate until the symptom passes. Victims may wish to ingest salt to help the symptom pass.
- Heat exhaustion. Symptoms include normal to slightly high body temperature, increased sweating, pale skin, dizziness, and fast pulse. Victims should rest in the shade and rehydrate until symptoms pass, then perform only light duty activities for the remainder of the work day.
- Heat stroke. Symptoms include high to extremely high body temperature and hot, red, and usually dry skin. Without immediate medical attention, victims may lapse into a coma and possibly die. Medical attention should be sought immediately. Unaffected site personnel should immediately cool victims by any means available. Victims should be moved quickly to any nearby air-conditioned area. Victim's clothing should be soaked in water. The victim should be fanned with a towel or other object to provide air movement.

31.1.2 Cold Stress

Examples of cold-related injuries include frostbite and hypothermia. Susceptibility to these injuries increases with increasing wind speed, wet conditions, and lack of insulated clothing. This section provides control actions and guidelines for cold working conditions.

Cold stress may be of particular concern when a wind-chill adjusted temperature of 10° F or less is expected. Personnel working outdoors in temperatures at or below freezing may be frostbitten. Working in extreme cold even for a short time may cause severe injury to the body surface or may result in profound generalized cooling, causing hypothermia and possibly death. Areas of the body that have a high surface area-to-volume ratio, such as ears, fingers, and toes, are most susceptible to frostbite.

Ambient temperatures and wind velocity influence the development of a cold injury. Wind chill (the chilling effect of moving air) should be taken into consideration along with the air temperature when determining whether or not outdoors work is safe.

When chemical-resistant equipment is removed and the clothing underneath is soaked with perspiration, the body cools very rapidly. Workers should therefore avoid removing equipment until they are in a warm area. Thermal socks, long cotton or thermal

underwear, hard-hat liners, and other cold-weather gear can help prevent hypothermia. Blankets, warm drinks (other than caffeinated coffee), and warm rest areas are essential to preventing cold-related injury.

Local body injury from exposure to cold is included in the generic term "frostbite." Frostbite symptoms can be categorized according to the following degrees of severity:

- Frostnip or initial frostbite is characterized by sudden blanching or whitening of the skin.
- Superficial frostbite causes the skin to have a waxy appearance and to be firm to the touch while the tissue underneath is resilient.
- Deep frostbite causes the skin to be cold, pale, and solid. This degree of frostbite is extremely serious.
- Systemic hypothermia manifests itself in five stages of symptoms, including: (1) shivering; (2) apathy, listlessness, sleepiness, and sometimes rapid cooling of the body to less than 95° F; (3) unconsciousness, glassy eyes, and slow respiration and pulse; (4) freezing of the extremities; and (5) death.
- Trench foot or immersion foot occurs when feet are kept cold and/or wet for an extended period of time. Feet become pale, cold, and possibly pulse less during recovery, feet become red, hot, and swollen from excessive blood flow. Trench foot is generally contracted in freezing temperatures (32° F or less), while immersion foot is contracted at non-freezing temps, generally below 50° F.

31.1.3 Meteorological Monitoring

The field team leader will note the wind direction, general weather conditions, and temperature each day. In addition, weather conditions will be monitored at the site trailer and important information will be relayed via two-way radios.

Field operations during summer can create a variety of hazards. Heat cramps, heat exhaustion, and heat stroke, if not remedied, can threaten health or life. Fieldwork during the winter can also cause health hazards, including hypothermia and frostbite. Therefore, as part of the initial site safety, health, and emergency briefing, personnel will be reminded of the symptoms of these conditions and the appropriate remedial actions. In addition, meteorological conditions of concern include thunderstorms, hail, high winds, heavy rains, and the possibility of tornadoes.

32 Accident Prevention Plan and Reporting

Personnel should immediately report all accidents or incidents to the field team leader. The field team leader will immediately ensure that necessary first aid and corrective actions have begun and, if necessary, that emergency agencies have been called. The field team leader will notify the site manager (if applicable) about the accident.

33 Site Specific Information

33.1 Base Operations

The helicopter will base out El Paso International Airport. Normal ATC communications will be used during the taxi / takeoff and climb out phase of the data collection flights on

the island. The pilots will be in contact with ATC and receive VFR traffic advisories during the flights.

33.2 Local Emergency Information

All health care facilities are located in El Paso, TX. The local hospital is University Medical Center El Paso. The hospital has a 24-hour emergency and labor and delivery service. If there is an emergency of any type one should dial 911. Local emergency services contact information is provided in Table 5.

Table 6. Emergency Contact Numbers for Ft. Bliss, TX

Emergency Service	Emergency No.	Non-emergency No.	Location
Police	911	(915) 541-4000	2 Civic Center Plaza, El Paso, TX 79901
Ambulance	911	(915) 779-2111	5720 Trowbridge Dr # B, El Paso, TX 79925
Fire	911	(225) 587-2237	3801 Fort Blvd El Paso, TX 79930
University Medical Center of El Paso	911	(915) 521-7602	4815 Alameda Ave El Paso, TX 79905
FAA		(915) 772-9412	2050 Hawkins Blvd, El Paso, TX 79925